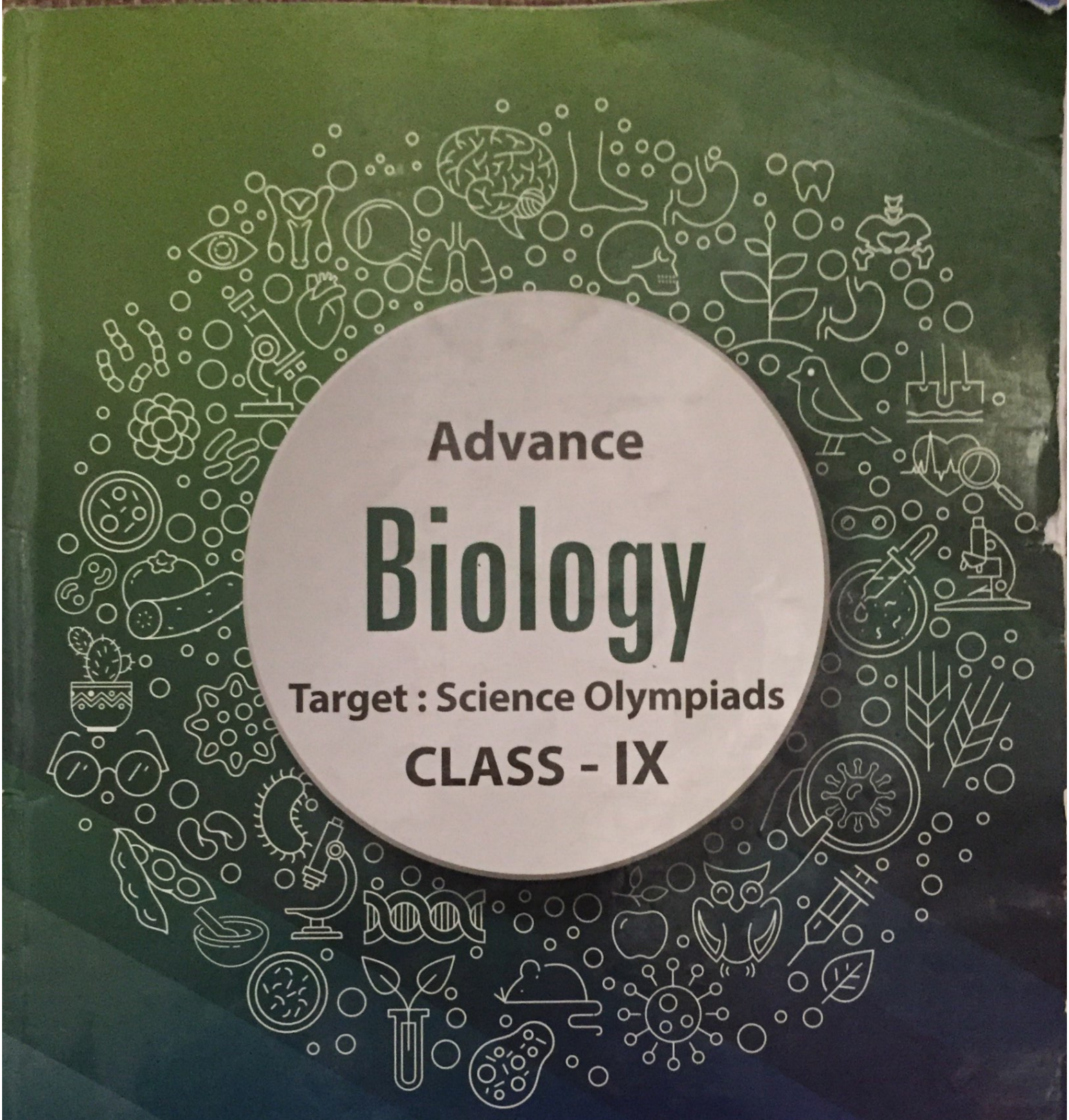

Advance

Biology

Target : Science Olympiads

CLASS - IX

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CHAPTER 1

Cell-unit of life

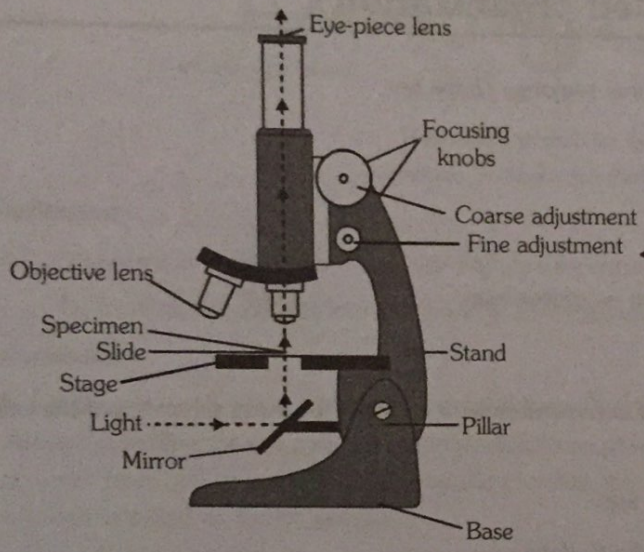
The cell is the basic unit of structure and function in living organisms.

Cytology : The branch of biology which deals with the study of structure and function of plant and animal cells.

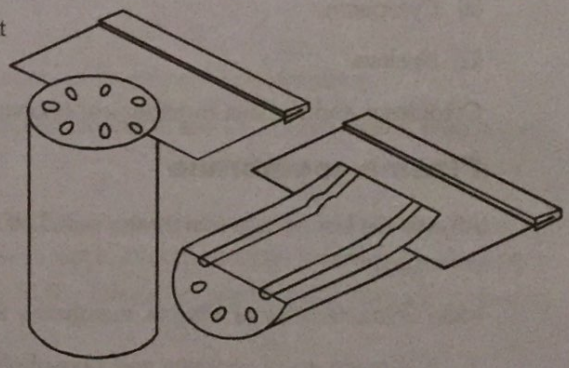
1.1 Invention of microscope

The simplest microscope was constructed in the year 1600 and later used by Galileo and Anton van Leeuwenhoek. In 1665 Robert Hooke observed a thin slice of cork (dead cell) under the microscope and saw honeycomb-like structures which he called cells. Actually it was dead cells of outer cover of the plant called periderm (bark).

Thin slice of any part is called sections. If you cut along the length, you are taking a longitudinal section and if you cut across the structure, you make a transverse section.



The microscope. Light is reflected by the mirror and directed through the specimen into the lenses of the microscope. These lenses produce a greatly magnified image of the specimen which can be studied directly or photographed.



(a) Transverse section (b) Longitudinal section

Working of a Microscope

(i) The object on a glass slide is kept on a stage bearing a central hole under an objective lens.
(ii) Light is reflected through the specimen with the help of a mirror and condenser from below the stage.
(iii) Through an eyepiece at the top of the microscope one can see the magnified image of the object.
(iv) Focusing is done by adjustors (coarse and fine) fitted in the microscope.
(v) Eyepiece lenses of magnification 5X, 10X, 15X and objective lenses of high (40X, 100X) and low (10X) powers are available.

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Cell size

Some cells are visible to the naked eye but most are microscopic in size, ranging from 10 to 100 microns. Example-ostrich egg having the largest volume in the animal cell and smallest cell is PPLO (pleuropneumonia like organism) which measures 0.1 to 0.5 μ. (1 μ =10^{-6} m).

Under microscope cells become magnified so we can observe them easily.

$$\text{Magnification} = \frac{\text{Observed size}}{\text{Actual size}}$$

In light microscope 10X and 45X types of objective lenses are there and eyepiece may have 10X or more type of lenses so magnification becomes 100X to 450X. The best light microscopes can magnify structures upto 1500 times their original size (× 1500).

Two major factors set the limit of cell size i.e.,

(i) nucleo-cytoplasmic ratio, which determines the range of control of metabolic activities by the nucleus and

(ii) ratio of surface area to volume.

1.2 Cell organization

All cells have three common major functional regions. These are

(i) Plasma membrane or cell membrane

(ii) Cytoplasm

(iii) Nucleus

Cytoplasm and nucleus together are known as protoplasm.

Plasma membrane

All cells are bound by a membrane called plasma membrane. It encloses the living substance of the cell called protoplasm.

Main characteristics of Plasma membrane are -

(i) It is made up of proteins and phospholipids (fats).

(ii) Proteins are scattered in the phospholipid bilayer.

(iii) It is selectively permeable i.e. only selective solute can pass through the membrane.

(iv) Most accepted model was given by Singer and Nicolson (1972) which is called fluid mosaic model.

(v) It is less than 1/10,000 mm in thickness or 70Å thick.

(vi) Structure of membrane can explain all the characteristic functions like diffusion, osmosis, movement of ions etc.

(vii) The polysaccharides attached to the membrane proteins or the lipids are involved in cell to cell recognition mechanism. e.g., fertilization (when sperm and egg recognize each other)

(viii) The lipid bilayer is a barrier to water and anything that is water soluble. But, the majority of a chemicals that need to pass in or out of the cell are water soluble. The protein molecules in the membrane act

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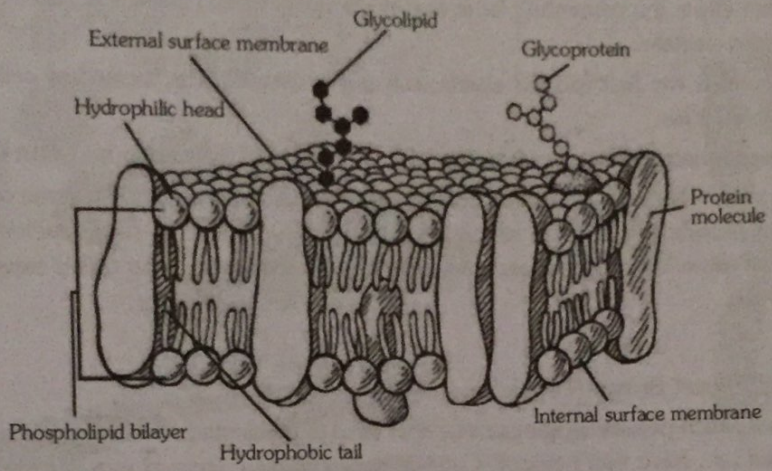
as hydrophilic pores, water-filled channels that allow water-soluble chemicals to pass through. Pores are usually small and highly selective i.e they allow only some molecules or ions to pass through them.

(ix) Water is a polar molecule (it has regions of positive and negative charge) and is a solvent for polar substances such as sugars, charged ions (Na^+, Cl^-, Ca^{2+}, K^+), B and C vitamins and amino acids. Polar substances do not dissolve in lipids and so can only cross a cell surface membrane by going through pores.

Most fats, oils and lipids are non-polar molecules (they do not have charged regions) and do not dissolve in water. Other non-polar substances (such as vitamins A, D, E and K) can dissolve in lipids and so can cross a cell surface membrane without going through pores.



Fluid mosaic structure of the plasma membrane by Singer and Nicolson (1972)

Diffusion

It is movement of substances from their higher concentration to their lower concentration.

e.g., O_2 from alveoli diffuses into the blood in the capillaries as blood has low O_2 concentration than alveoli.

Osmosis

It is a process in which water molecules move from their higher concentration to their lower concentration through a semipermeable membrane (only solvent can pass through this type of membrane). e.g., absorption of water from soil by roots. The hydrostatic pressure due to the amount of water inside the cell, caused by osmosis is called as turgor pressure.

According to permeability, membranes are of following types :

(i) Permeable-solvent and solute can pass.

(ii) Semipermeable-only solvent can pass.

(iii) Selectively permeable-solvent and selected solutes can pass.

(iv) Impermeable-nothing can pass.

Active transport

Active transport is the movement of any substance through the cell membrane that requires energy. The energy is provided by adenosine triphosphate (ATP) produced by aerobic respiration in the mitochondria. Active transport is a rapid process and is usually unidirectional. Some membrane proteins act as carrier molecules and transport the substance to the other side of the membrane.

Transport proteins are complex molecules embedded in the cell membrane which help move substances into and out of the cell.

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Cell wall

(i) It is only found in plants, fungi and bacterial cells.
(ii) It is an additional protective covering outside the cell membrane which makes the cell rigid.
(iii) It is made up of cellulose which is a type of carbohydrate.
(iv) Cell wall is dead and permeable for all type of solutes and solvents.
(v) It gives shape to the plant cell.
(vi) Being rigid it provides mechanical strength to the cell.
(vii) Cell wall is made up with middle lamella, primary wall and secondary wall.
(viii) The middle lamella is the cementing layer and is common to two cells. It is mainly composed of calcium and magnesium pectate.
(ix) The primary wall is the first formed elastic wall and is thinner. It is formed of cellulose microfibrils and pectin polysaccharides.
(x) The thicker secondary wall occurs inner to the primary wall in mature and non-dividing cells only.

Cell wall material in all eubacteria and cyanobacteria is peptidoglycan or murein. In some cells an extra protective layer may present outside the cell wall which is known as Glycocalyx. In some bacteria it is in the form of loose sheath called slime layer, other may have a thick and tough covering called capsule. In fungi cell wall is made up of chitin.

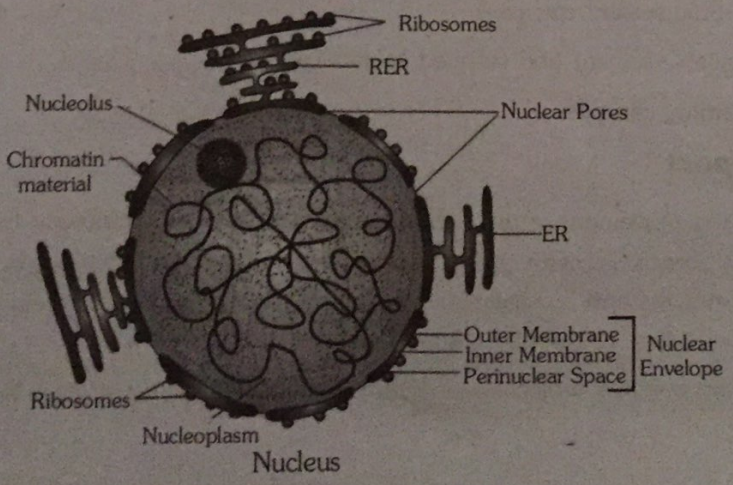
Nucleus

(i) Discovered by Robert Brown (1831).
(ii) Most of the cell which possess single nucleus are called uninucleated. Certain protista such as Paramecium are binucleated i.e., have two nucleus. Cells of bone marrow, striated muscles, certain algae and fungi possess many nuclei and are called multinucleated.
(iii) Nuclear envelope is double membranous structure that surrounds the nucleus and separates the cytoplasm.
(iv) Nuclear envelope is having pores which are called nucleopores that allows large macromolecules and ribosomes to pass through them.
(v) Nucleus contains nucleoplasm which contains nucleoproteins, nucleotides and number of enzymes.
(vi) All above material is required to synthesize DNA (deoxy ribonucleic acid) which is a genetic material.
(vii) DNA forms the condensed structures at the time of cell division called chromosomes which control the hereditary characters.

On the basis of the presence or absence of a well developed nucleus, organisms can be of two types

(1) **Prokaryotes :** Organisms, whose cells lack a nuclear membrane and the genetic material lies freely in the form of nucleoid, are known as prokaryotes. e.g Bacteria, blue green algae.

(2) **Eukaryotes :** Organisms, whose cells have a well organized nucleus with nuclear membrane are known as eukaryotes. e.g All plant and animal cells.



Nucleus

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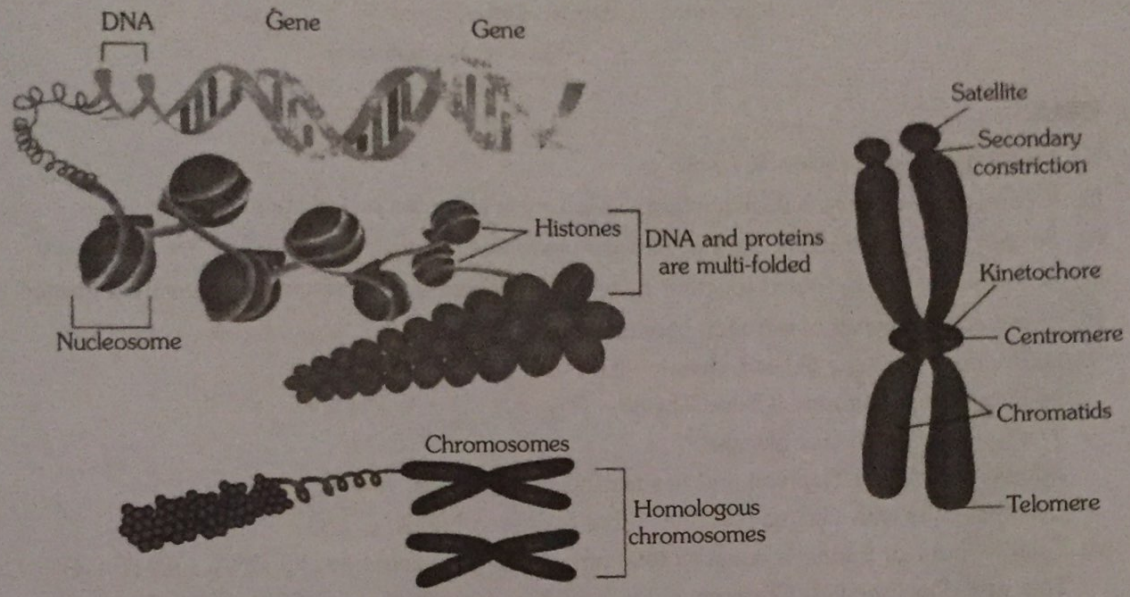
Structure of Chromosomes

The most ideal time to study the structure of a chromosome is the metaphase stage of mitosis in cell division because chromosomes are highly condensed at this stage of cell division. The gross structure of metaphase chromosome shows the following parts:

(i) A chromosome consists of two identical halves, the chromatids, held together at one point, the centromere.

(ii) Each sister chromatid has a kinetochore, a specialized protein structure located at the centromere.



Chromatin and condensed chromosome structure

(iii) A chromatid contains a single fine chromatin fibre, which is very long and greatly coiled to be accommodated in a short chromatid. The chromatin fibre is composed of DNA, combined with histone proteins.

(iv) The terminal parts of linear chromosome are called telomeres. They are regions of highly repetitive DNA. Telomere prevents the adhesion of one chromosome to another at the telomeric ends. When a chromosome breaks, the telomeric ends ensure that the broken chromosomes are reunited at the broken end only.

(v) The electron microscope shows a chromatin fibre as a chain of repeating units called nucleosomes.

(vi) The central part or core of a nucleosome is made up of histone proteins around which DNA is coiled.

(vii) The part of the DNA that connects two adjacent nucleosomes is called linker DNA or spacer DNA.

Classification of Chromosomes

A chromosome may have either equal or unequal arms depending on the position of the centromere. Accordingly, the chromosomes are of four types :

(a) Metacentric chromosome: Here, the centromere is near the middle and the two arms are almost equal in length.

(b) Submetacentric chromosome: The centromere is slightly away from the middle point and consequently its one arm is slightly shorter than the other arm.

(c) Acrocentric chromosome: Here , the centromere is near the end and consequently its one arm is very short and the other arm is very long.

(d) Telocentric chromosome : The centromere is at the tip of chromosome and the arm is on one side only.

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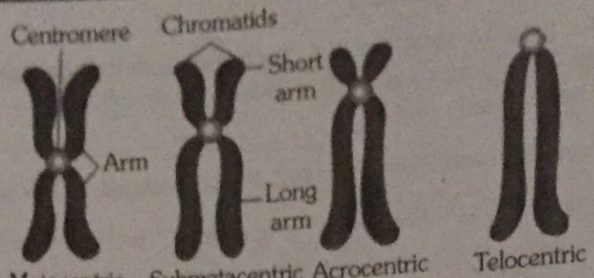


Types of chromosomes

DNA

(i) Model given by - Watson & Crick.

(ii) It consist of two polynucleotide chains which form a double helical staircase.

(iii) Single nucleotide is made up with nitrogenous bases, phosphate group and pentose sugar.

(iv) Both the chains are joined together by weak hydrogen bonds present between the nitrogen bases.

(v) There are two types of nitrogen bases.

(a) Purines - Adenine (A) and Guanine (G)

(b) Pyrimidine - Cytosine (C) and Thymine (T)

The pairing is such that always:

Adenine pairs with Thymine and has two hydrogen bonds, A = T

Cytosine pairs with Guanine and has three hydrogen bonds, C ≡ G

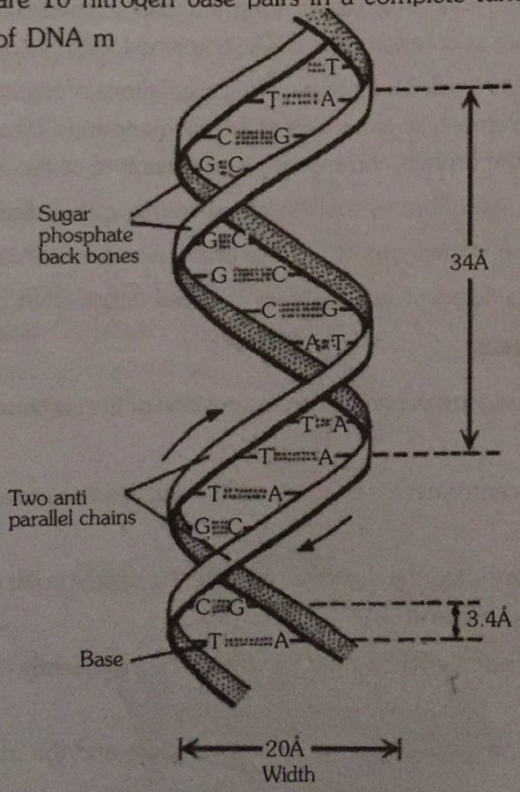
(vi) Total amount of purine is equal to total amount of pyrimidine in any DNA. i.e., A + G = C + T.

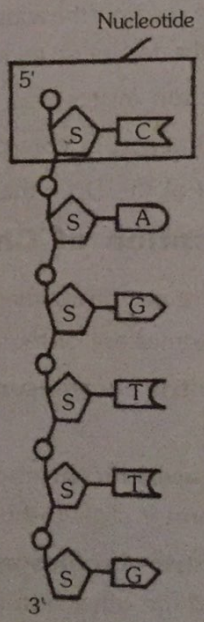
This was established by Chargaff and is known as Chargaff's rule of base equivalence.

(vii) Double helix is twisted. It takes a complete turn after every 34 Å.

(viii) There are 10 nitrogen base pairs in a complete turn (34 Å).

(ix) Width of DNA m





RNA ribo nucleic acid genetic material eg: Viruses

DNA - Deoxyribo nucleic acid

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Significance of DNA

(i) DNA controls all the activities of the cell, both directly and indirectly. The unique feature of the DNA is its property of duplicating itself during cell division (replication).

(ii) It is the genetic material. It contains the genetic code which guides the synthesis of proteins. DNA synthesises RNA which helps in protein synthesis.

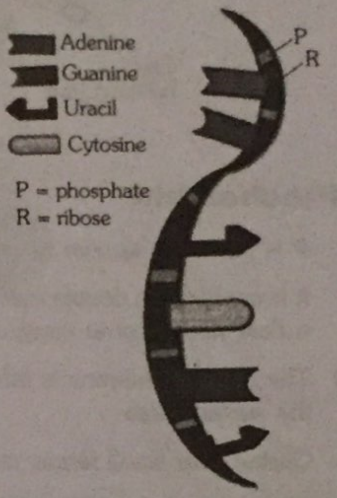
(iii) DNA can undergo mutations and recombinations to bring about variations, which play an important role in speciation (formation of new species from preexisting forms).

Ribonucleic Acid

RNA occurs in all living cells and in viruses. In eukaryotic cells, more than 90% of the RNA is found in the cytoplasm and the rest in the nucleus. RNA has been found to be the genetic material in some plants, animals, viruses, and in bacteriophages. Such RNA is called the genetic RNA. In other organisms, where the genetic information is contained in the DNA, RNA occurs in the nucleus, cytoplasm, ribosomes, chloroplasts, and mitochondria. Such an RNA is called non-genetic RNA.

Like DNA, RNA is a macromolecule and is a polynucleotide chain. But it is a single-stranded molecule and is shorter than the DNA molecule. It may twist by itself so as to form loops and helical regions. The pentose sugar in RNA is ribose.

RNA occurs in three forms. They are messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA).



A portion of RNA molecule

Gene

(i) Each chromosome consists a number of genes.

(ii) A gene is a short segment of DNA.

(iii) Genes are arranged in a linear order on a chromosome.
Each gene has a specific position and carry specific function.
At times a set of genes is required for a single function.

Nucleolus

It is naked, rounded or irregular body which is attached to chromatin at specific region. It was discovered by Fontana (1781) and present name was given by Bowman (1840). A nucleolus has four regions-amorphous matrix, granular region, fibrillar region and chromatin part.

Functions of nucleus

(i) It contains all the genetic information required for the growth, development of the organism, reproduction, metabolism and behavior.

(ii) It passes all the genetic information to the daughter cells.

(iii) Nucleus takes part in the formation of ribosome.

(iv) It develops genetic variations that contribute in evolution.

(v) It controls all metabolic activities of cell.

Nucleoid

In prokaryotes true nucleus is absent and the genetic material lies freely in the cytoplasm known as nucleoid.

Golgi body

(i) In 1898 Camillo Golgi discovered this apparatus in nerve cell of owl and cat.

(ii) In animal cell it is localized near the nucleus but in plant cell it is in the form of unconnected units called dictyosomes.

(iii) It is composed of cisternae, vesicles, tubules and vacuoles. Golgi body is single membrane covering.

(iv) Functions of golgi body are-secretion, formation of carbohydrates, glycoproteins, cell wall, cell membrane,

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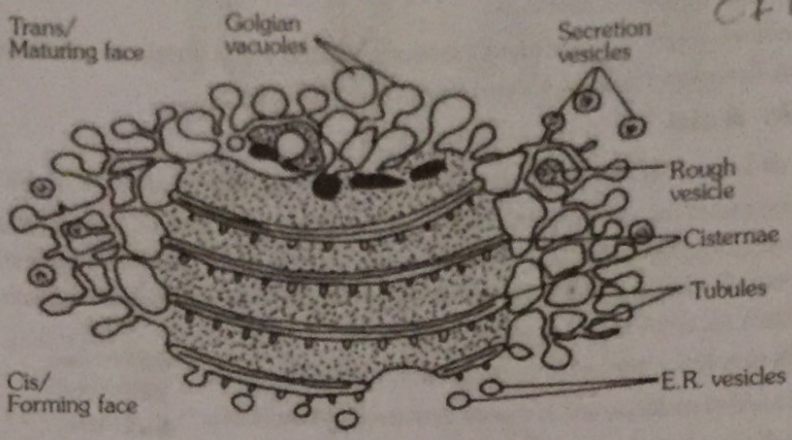
lysosomes, acrosome of sperm, cell plate formation.

(v) Cisternae are stacked one above the other and form shallow bowl like structure.

(vi) The convex side called forming or cis face lies towards the nucleus, while the concave side called maturing or trans face lies towards the plasma membrane.



Golgi Complex

Mitochondria

(i) It is popularly known as power house of the cell or ATP generation site.

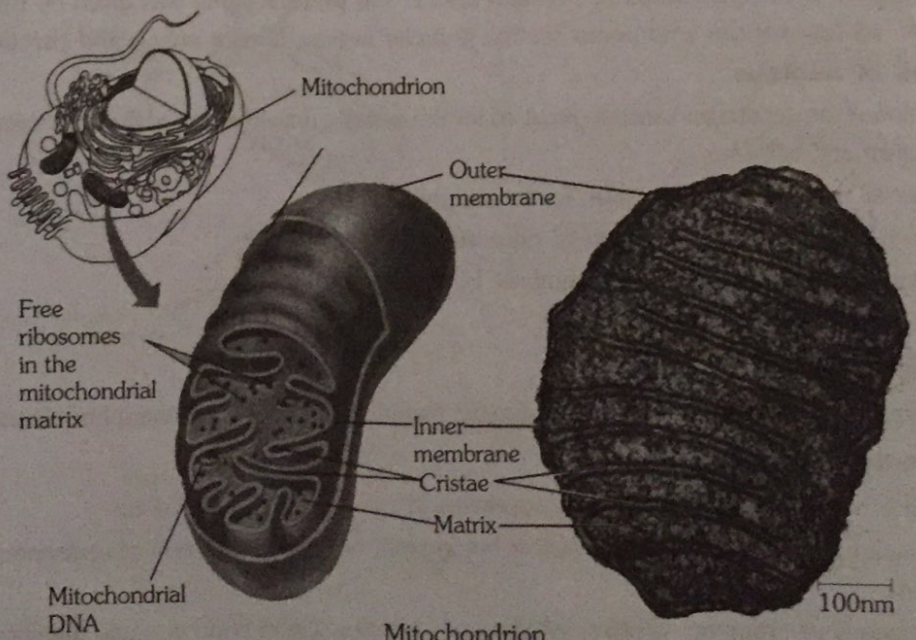
(ii) It is enclosed in double membrane envelop. Outer membrane is smooth but inner membrane surrounds a fluid filled central cavity called matrix.

(iii) The inner membrane is infolded into the matrix as incomplete partition called cristae, which increase the surface area.

(iv) Cristae bear small tennis racket like particles called elementary particles, F_0-F_1 particles or oxysomes.

(v) These particles are associated with respiration and formation of energy in the form of ATP (adenosine tri phosphate) so mitochondria is called as power house of the cell.

(vi) Mitochondria is a semi autonomous body because it has its own DNA and ribosome and can self replicate.



Mitochondrion

ATP is a form of energy which is synthesized by the mitochondria and stored for further use.ATP synthetase

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enzyme is responsible for the formation of ATP.

Plastids

(i) Plastids are semi autonomous organelles having DNA and double membrane envelope.

(ii) Depending upon colour, plastids are of three types-leucoplasts, chromoplasts and chloroplasts.

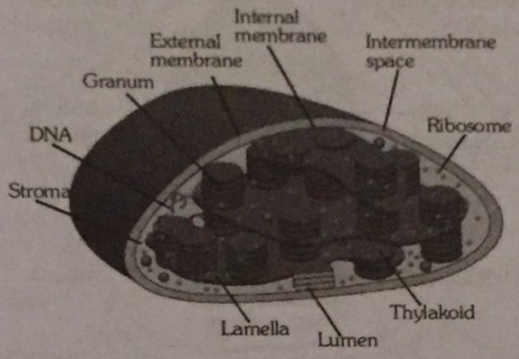
(iii) Leucoplast is colorless and used to store proteins (Aleuroplast), oil (Elaioplasts) and starch (Amyloplast).

(iv) Chromoplast are colored and contain pigments other than green.

(v) Chloroplast is green which takes part in the synthesis of organic food (by photosynthesis).

(vi) The ground substance is called stroma, number of membranous structures called thylakoids run throughout the stroma. Thylakoids have chlorophyll and are placed one above the other like stack of coins to form grana.

(vii) Main functions are photosynthesis, storage of fats, proteins and starch.



Chloroplast

Endoplasmic reticulum

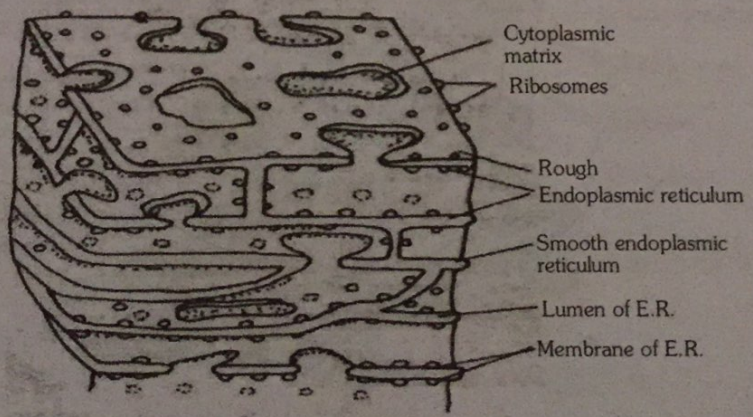
(i) ER is a three dimensional complicated and interconnecting system of membrane lined channels that run through the cytoplasm.

(ii) It remain continuous with the plasma membrane, nuclear envelope and Golgi body.

(iii) ER is made up with cisterne, vesicles and tubules. Depending upon the nature of the membrane it is of two types-smooth ER and rough ER.

(iv) SER is engaged in the synthesis and storage of glycogen, fat and steroids and detoxification of drugs and poisons.

(v) RER is associated with protein synthesis because of ribosomes present on its surface.



Endoplasmic Reticulum

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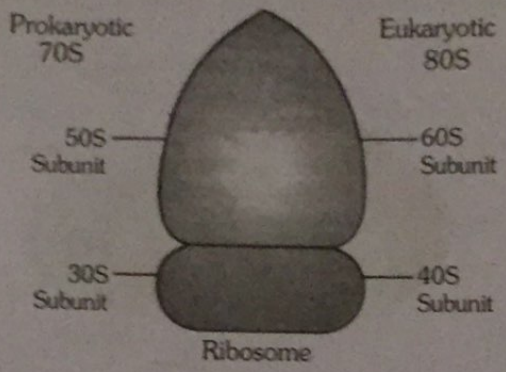
Ribosomes

(i) Ribosomes are also called "organelle within an organelle" and protein factory of the cell.
(ii) Ribosome is small sub-spherical granular organelles, not enclosed by any membrane.
(iii) Each ribosome is made up with two unequal sub units which join together only at the time of protein synthesis in the presence of Mg^{2+} ions in specific concentration.
(iv) They are made up with r-RNA and proteins. At the time of protein synthesis, they attach with m-RNA and form polyribosome.
(v) In prokaryotes the two sub units are 30S and 50S (together 70 S) and in eukaryotes they are 40S and 60S (together 80S).
(vi) Most ribosomes occurs in clusters of two to six attached to messenger RNA (m-RNA) called polyribosomes or polysomes.
(vii) In mammals 55 S type of ribosomes are present in mitochondrial matrix.

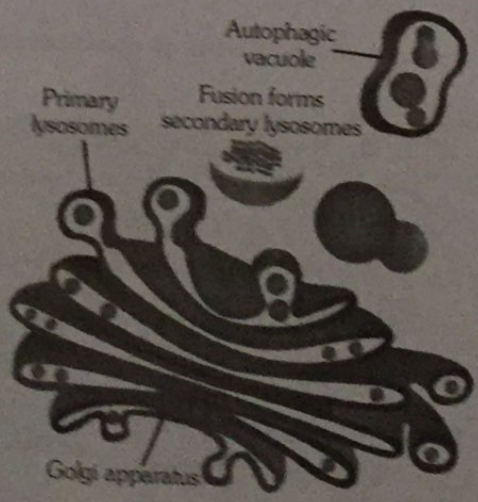


Lysosomes

Lysosomes were first reported by Christian de Duve in 1955. They occur in most animal cells and in the meristematic cells of a few plants. They are absent in bacteria and mature mammalian erythrocytes.

Structure

Lysosomes are tiny, membrane-bound, vesicular structures of the cytoplasm which perform intracellular digestion of the cell. They are polymorphic (i.e., of four types) - primary lysosomes, secondary lysosomes, residual bodies, and autophagic vacuoles. Lysosomes regularly engulf bits of cytosol containing waste (foreign material and worn out cell organelles), which are digested there. Lysosomes contain digestive enzymes capable of digesting proteins, carbohydrates, lipids, and nucleic acids.



Lysosomes

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Functions

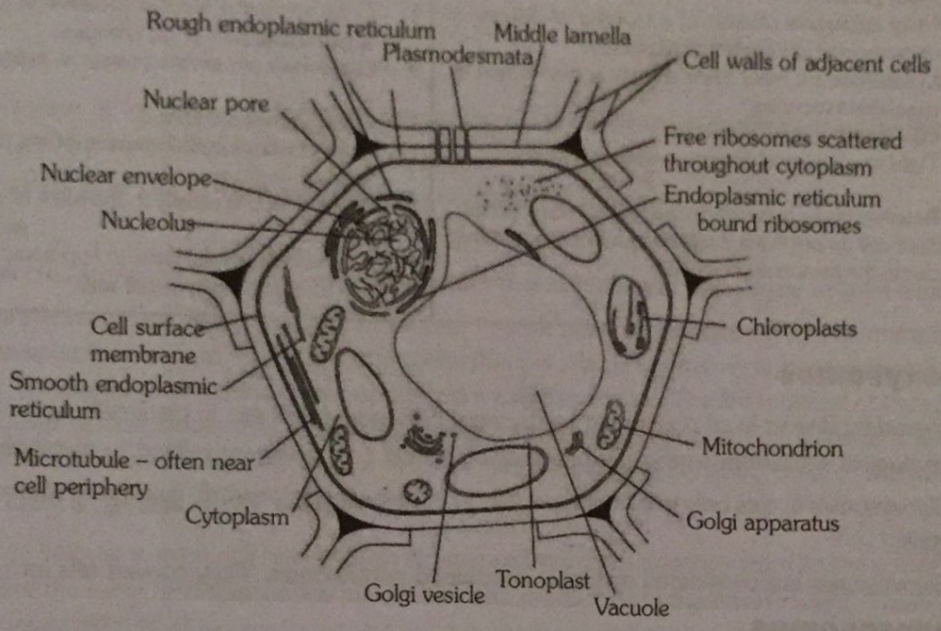
(i) Lysosomes are involved in the digestion of microorganisms such as bacteria entering the cell by phagocytosis.

(ii) In certain conditions, lysosomes start to digest the various organelles of cells and this process is known as autolysis. Hence, lysosomes are called digestive bags.

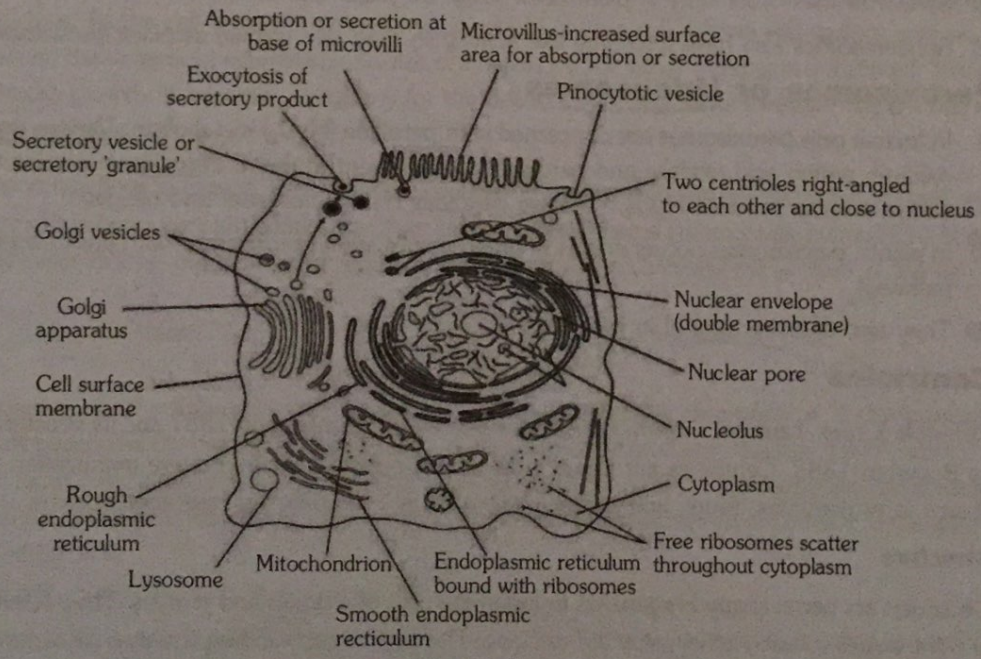
(iii) Lysosomes are sometimes called suicide bags because the enzymes they contain could digest the whole cell if they burst.

(iv) Lysosomal enzymes are used in the process of apoptosis (i.e., the programmed cell death . For example, the gradual disappearance of tail in tadpole during metamorphosis is due to lysosomal enzymes.

Difference between plant cell and animal cell



Plant cell



Animal cell

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Plant Cell	Animal cell
1. A plant cell is usually larger in size.	1. An animal cell is comparatively smaller in size.
2. A rigid cell wall in addition to plasma membrane.	2. It is enclosed by a thin, flexible plasma membrane only.
3. It can not change its shape.	3. An animal cell can often change its shape.
4. Plastids are present. Plant cells exposed to sunlight contain chloroplast.	4. Plastids are usually absent,
5. A mature plant cell contains a large central vacuole.	5. An animal cell often possesses many small vacuoles.
6. Nucleus lies on one side in the peripheral cytoplasm.	6. Nucleus usually lies in the centre.
7. Centriole are usually absent except in motile cells of lower plants.	7. Centriole is practically present in all animal cells.
8. Golgi apparatus consists of a number of distinct or unconnected units called dictyosomes.	8. Golgi apparatus is either localized or consists of a well connected single complex.
9. Lysosomes are rare. Their activity is performed by specialised vacuoles.	9. Lysosomes are always present in animal cells.
10. Glyoxysomes may be present.	10. Glyoxysomes are absent.
11. Tight junctions and desmosomes are lacking.	11. Tight junctions and desmosomes are present between cells.
12. Reserve food is generally in the form of starch or fat.	12. Reserve food is usually in the form of glycogen and fat.
13. Plant cell do not burst if placed in hypotonic solution due to the presence of cell wall.	13. Animal cells usually burst in hypotonic solution due to the absence of cell wall.

Glyoxysomes

Discovered by Beever in oil containing seeds, yeast cells, guard cells etc. In plant cells, some organelles show morphological similarities to the peroxisomes of animal cells They are related to metabolism of fats.

(i) Glyoxysomes occurs only in plants especially in fatty seeds (castor seed), guard cells of stomata and unripe fruits.

(ii) Glyoxysomes are considered as highly specialised peroxisomes. They convert fats into carbohydrates.

Sphaerosomes

(i) Sphaerosomes occur only in plant cells. They are major site of lipid storage and synthesis in plants.

(ii) Sphaerosomes also have lysosome like activity so they also termed as plant lysosomes.

Peroxisomes or Uricosomes

(i) In animal cells peroxisomes are concerned with peroxide (H_2O_2) metabolism, Various enzymes like urate oxidase, amino acid oxidase and peroxidase are present in them. Peroxidase induces the oxidation of amino acids to produce H_2O_2. Catalase degrades H_2O_2 into water and oxygen.

(ii) In plants, peroxisomes occurs in cells of green tissues and are concerned with photorespiration (glycolate pathway).

(iii) They also detoxify alcohol in liver cells.

Centrioles

Centriole (Greek, centrum = centre) was discovered by Van Beneden in 1887 and its structure was elaborated by Boveri in 1888. Centrioles are found in all animal cells except the mature mammalian RBCs. They are absent in prokaryotes, fungi, and higher plant such as gymnosperms and angiosperms.

Structure

Centrioles are barrel-shaped organelles found in the cells of animals and protists. They occur in pairs, usually at right angles to each other near the nucleus. The region surrounding the pair of centrioles is known as centrosphere. Centrioles along with centrosphere is known as centrosome. Each centriole is a short cylinder with a 9 + 0 pattern of microtubule triplets, that is, a ring having nine sets of peripheral triplets with none in the middle.

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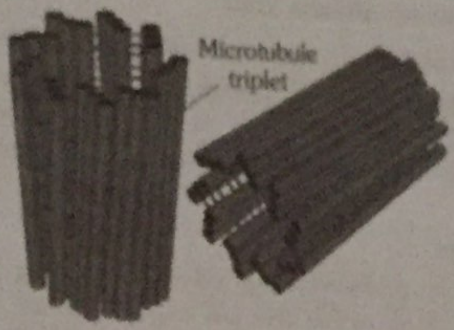

Centriole

Functions

(i) At the time of cell division, centrioles move to the poles and from asters which organise the spindle fibres during the process of cell division.

(ii) Centrioles give rise to cilia and flagella in animal cells.

Vacuoles

Vacuoles are membrane bound non-cytoplasmic sacs that contain non living liquid or solid contents.

They are common fluid filled vacuoles which occur in both plant and animal cells. In animal and young plant cells, sap vacuoles are small. In mature plant cells, there is a large central vacuole occupying 50–90% of cell volume. The covering membrane of the sap vacuole is called tonoplast. The fluid content of the vacuole is called cell sap. Sap vacuole stores salts, sugar, amino acid, organic acids and some proteins. It is also a dump for waste products in plant cells. Sap vacuole helps in maintaining turgidity and rigidity of the cell.

Why cells grow and divide ?

In order to keep alive, every cell has to obtain organic and inorganic materials from its immediate environment, metabolise the same, and dispose the metabolic waste products into the environment. These processes not only generate the flow of bioenergy but also result in the biosynthesis of macromolecular components, which lead to the steady growth of cells. The metabolic reactions are controlled by the genetic material present in the nucleus. As the cell grows, the normal equilibrium between cell volume and surface area on one hand and between the volume of cytoplasm and size of nucleus on the other hand gets distributed. After attaining the optimum growth, it becomes obligatory for the cell to divide and restore equilibrium if it has to survive.

Cell Division

Cell division functions in growth, repair, and reproduction. Two types of cell division occur, mitosis and meiosis. Mitosis produces two genetically identical daughter cells and conserves the chromosome number (2n). Meiosis occurs in sexually reproducing organisms and results in cells with half the chromosome number of the parent cell (n).

Mitosis : $2n \rightarrow 2n + 2n$

Meiosis : $2n \rightarrow n + n + n + n$

Any discussion about cell division must first consider the structure of the chromosome. A chromosome consists of a highly coiled and condensed strand of DNA. A replicated chromosome consists of two chromatids, where one is an exact copy of the other. The centromere is a specialized region that holds the two chromatids together. The kinetochore is a disc-shaped protein on the centromere that attaches the chromatid to the mitotic spindle during cell division.

The cell cycle

Living and dividing cells pass through a regular sequence of growth and division called the cell cycle. The timing and rate of cell division are crucial to normal growth and development. Two important factors limit cell size and promote cell division, the ratio of the volume of a cell to the surface area and the capacity of the nucleus.

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Ratio of the cell volume to surface area

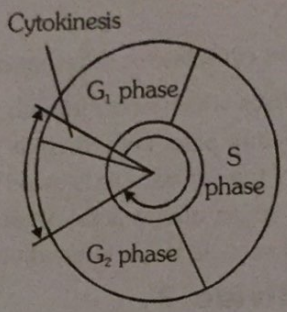
As a cell grows, the area of the cell membrane increases as the square of the radius while the volume of the cell increases as the cube of the radius. Therefore, as a cell grows larger, the volume inside the cell increases at a faster rate than does the cell membrane. Since a cell depends on the cell membrane for exchange of nutrients and waste products, the ratio of cell volume to membrane size is a major determinant of when the cell divides.

Capacity of the Nucleus

The nucleus must be able to provide enough information to produce adequate quantities to meet the cell's needs. In general, metabolically active cells are small. However, cells that have evolved a strategy to exist as large, active cells exist in several kingdoms. Large sophisticated cells like Paramecium have two nuclei and each controls different cell functions. Human skeletal muscle cells are giant multinucleate cells. The fungus slime mould actually consists of one giant cell containing thousands of nuclei.

Phases of the cell cycle

The cell cycle consists of five major phases: G_1, S, and G_2 (which together are called interphase), mitosis, and cytokinesis.



Interphase

Interphase consists of G_1, S, and G_2 phases. The G_1 phase is a period of intense growth and biochemical activity. S stands for the synthesis or replication of DNA. G_2 is the phase when the cell continues to grow and to complete preparations for cell division. More than 90 percent of the life of a cell is spent in interphase. When a cell is in interphase and not dividing, the chromatin is threadlike, not condensed. Within the nucleus are one or more nucleoli. Centrosomes, consisting of two centrioles, can be seen in the cytoplasm of an animal cell. Plant cells lack centrosomes but have microtubule organizing centers, MTOCs.

Mitosis

Mitosis consists of the actual dividing of the nucleus. It is a continuous process. However, scientists have divided it into four arbitrary divisions: prophase,metaphase, anaphase, and telophase. Here are the characteristics of each phase.

Prophase

- The nuclear membrane begins to disintegrate.
- The strands of chromosomes begin to condense into discrete observable structures.
- The nucleolus disappears.
- In the cytoplasm, the mitotic spindle begins to form, extending from one centrosome to the other.
- Prophase is the longest phase of mitosis.

Metaphase

- The chromosomes line up in a single file located on the equator or metaphase plate.
- Centrosomes are at opposite poles of the cell.
- Spindle fibers run from the centrosomes to the kinetochores in the centromeres.

Anaphase

- Centromeres of each chromosome separate and spindle fibers pull apart the sister chromosomes.
- This is the shortest phase of mitosis.

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Telophase

- Chromosomes cluster at opposite ends of the cell, and the nuclear membrane reforms.
- The supercoiled chromosomes begin to unravel and return to their normal, pre-cell division condition as long, thread like strands.

Cytokinesis

Cytokinesis consists of the dividing of the cytoplasm. It begins during mitosis, often during anaphase. In animal cells, a cleavage furrow forms down the middle of the cell as actin and myosin microfilaments pinch in the cytoplasm. In plant cells, a cell plate forms during telophase as vesicles from the Golgi moves down the middle of the cell. Daughter plant cells do not separate from each other. A sticky middle lamella cements adjacent cells together.

Meiosis

Meiosis is a form of cell division that produces gametes (sex cells, or sperm and ova) with the haploid chromosome number (23). There are two stages in meiosis. Meiosis I (Reduction division) is when homologous chromosomes separate. Meiosis II (Equational division) is like mitosis. In meiosis I, each chromosome pairs up precisely with its homologue into a synaptonemal complex by a process called synapsis and forms a structure known as tetrad or bivalent. Synapsis is important for two reasons. First, it ensures that each daughter cell will receive one homologue from each parent. Second, it makes possible the process of crossing-over by which homologous chromatids exchange genetic material. Crossing-over is a common and highly organized mechanism to ensure greater variation among the gametes. In meiosis II, sister chromatids separate. The two stages of meiosis are further divided into phases. At the beginning of meiosis cells have the diploid chromosome number. By the end of meiosis cells contain the monoploid or haploid chromosome number (n). Each meiotic cell division consists of the same four stages as mitosis: prophase, metaphase, anaphase and telophase.

Meiosis I

Prophase I

- Synapsis and crossing-over occur. Chiasmata, the visible manifestations of the cross-over events, are visible.
- This is the longest phase.

Metaphase I

- The homologous pairs of chromosomes are lined up in double file along the metaphasic plate.
- Spindle fibers from the poles of the cell are attached to the centromeres of each pair of homologous chromosomes.

Anaphase I

- Homologous chromosomes are separated as they are pulled by spindle fibers and migrate to opposite poles.

Telophase I

- Homologous pairs continue to separate until they reach the poles of the cell. Each pole has the monoploid number of chromosomes.

Cytokinesis I

- Cytokinesis usually occurs simultaneously with telophase I.

In some species, an interphase occurs between meiosis I and meiosis II. In other species, it does not occur. In either case, chromosomes do not replicate between meiosis I and II because chromosomes already exist as double or replicated chromosomes.

Meiosis II

Meiosis II is functionally the same as mitosis and consists of the same phases: prophase-II, metaphase-II, anaphase-II, telophase-II, and cytokinesis. The chromosome number remains haploid, and daughter cells are genetically identical to the parent cell.

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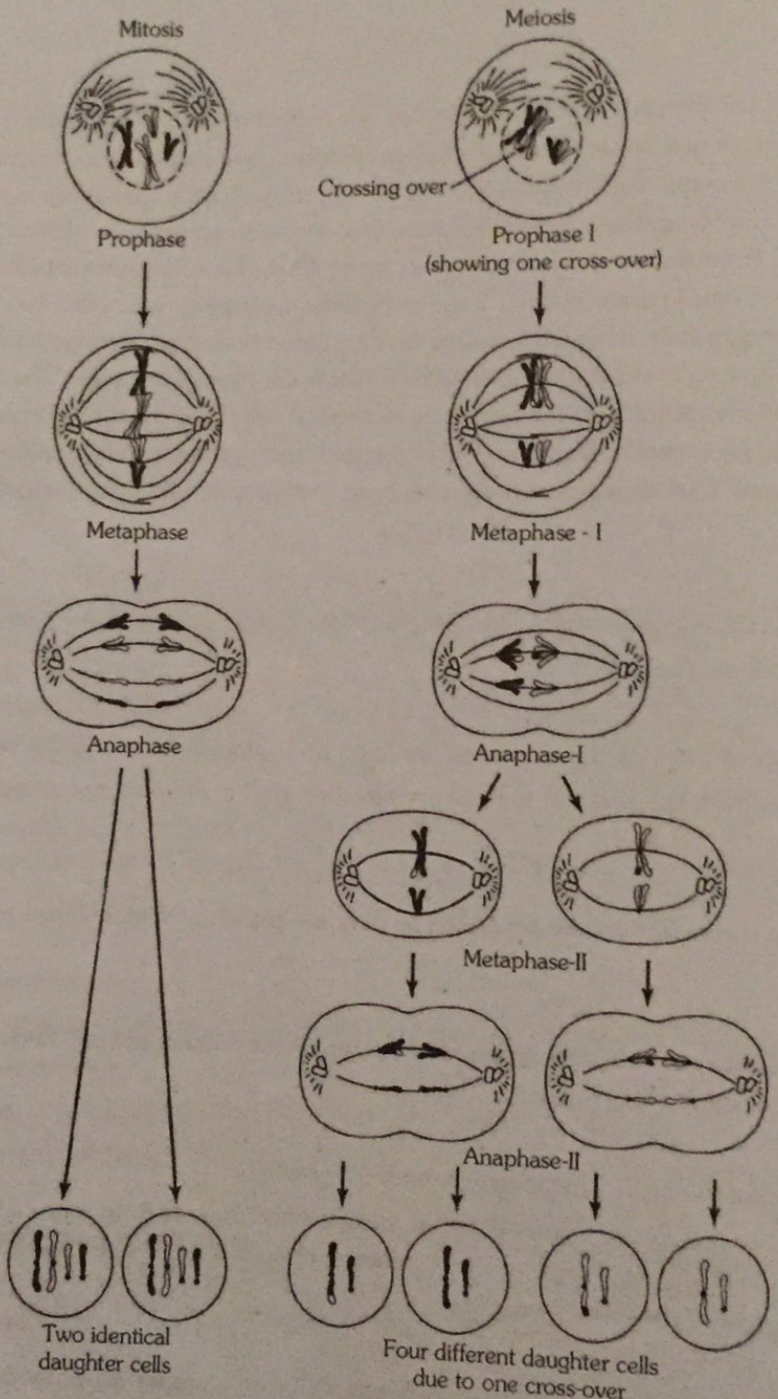
Meiosis and Genetic Variation

Three types of genetic variation result from the processes of meiosis and fertilization. They are independent assortment of chromosomes, crossing-over, and random fertilization of an ovum by a sperm. Independent assortment of chromosomes during meiosis occurs as homologous pairs of chromosomes separate depending on the random way in which they line up on the metaphase plate during metaphase. There is a 50 percent chance that a particular gamete will receive a maternal chromosome and a 50 percent chance it will receive a paternal chromosome. Crossover produces recombinant chromosomes that combine genes inherited from both parents. In addition, at metaphase II, these recombinant chromosomes line up on the metaphase plate in random fashion. This increases the possible types of gametes even more.



Comparison of Mitosis and Meiosis

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Difference between prokaryotic & eukaryotic cell		
Characteristic	**Prokaryotes**	**Eukaryotes**
Size of cell	Typically 0.2-2.0 μ m in diameter	Typical 10-100 μm in diameter
Nucleus	No nuclear membrane or nucleoli	True nucleus, consisting of nuclear membrane & nucleoli
Membrane enclosed organelles	Absent	Present ; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria, chloroplasts
Cell wall	Usually present ; made up of peptidoglycan	When present, made up of cellulose or chitin
Plasma membrane	No carbohydrates and generally lacks steroid	Steroids and carbohydrates that serve as receptors are present
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton ; cytoplasmic streaming present
Ribosomes	Smaller size (70S)	Larger size (80S) ; smaller size (70S) in organelles
Chromosome	Single circular chromosome	Multiple linear chromosomes
Cell division	Binary fission/ Amitosis	Mitosis, meiosis

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EXERCISE

Multiple choice questions

1. Fluid mosaic model of cell membrane state that it has lipid bilayer with
(1) Proteins on both the surface (2) Proteins on the outer surface only
(3) Proteins embedded in it only (4) Some proteins embedded and some on the surfaces

2. Fluid mosaic model of cell membrane was proposed by
(1) Robertson (2) Daniell and Davson (3) Singer and Nicolson (4) Watson and Crick

3. Which is true for active and passive transport?
(1) Active transport is found in animals whereas passive transport is found in plants.
(2) Active transport require energy whereas passive transport follows concentration gradient.
(3) Active transport in connected with cations, whereas passive transport is related to anions.
(4) Active transport is random whereas passive transport is selective.

4. Cell recognition and adhesion is facilitated by certain components of cell membrane. These components are generally
(1) Proteins and lipids (2) Glycoproteins and glycolipids
(3) Lipids only (4) Proteins only

5. If a solution outside a cell is made more concentrated so that the cell loses water to its environment and shrinks, the external solution is said to be_____to the cell contents.
(1) Hypotonic (2) Isotonic (3) Hypertonic (4) Sugar Solution

6. Cell drinking is a term used for
(1) Pinocytosis (2) Phagocytosis (3) Endocytosis (4) Exocytosis

7. Solar energy is converted into ATP/chemical energy by
(1) Mitochondria (2) Peroxisome (3) Ribosome (4) Chloroplast

8. Cell wall shows
(1) Semi permeability (2) Permeability
(3) Impermeability (4) Differential permeability

9. Photorespiration occurs in plant cells in
(1) Dictyosomes (2) Glyoxisomes (3) Peroxisomes (4) Endoplasmic reticulum

10. A membranous bag containing hydrolases used for intracellular digestion of macromolecules in a cell is called
(1) Ribosome (2) Lysosome (3) Nucleosome (4) Chromosome

11. Outer and inner membranes of mitochondria are
(1) Structurally and functionally similar
(2) Structurally and functionally different
(3) Structurally similar but functionally differrent
(4) Structurally different but functionally similar

12. A membrane covering is lacking around
(1) Lysosome (2) Nucleolus
(3) Mitochondria (4) Plastid

13. Normally, in the process of osmosis, the net flow of water molecules in or out of the cell depends upon differences in the
(1) Concentration of water molecules inside and outside the cell
(2) Concentration of enzymes on either side of the cell membrane
(3) Rate of molecular motion on either side of the cell membrane
(4) Rate of movement of insoluble molecules inside the cell

14. The bacterial cell wall is composed of
(1) A phospholipid matrix (2) A lipoprotein
(3) Chitin (4) A polymer of sugars (Peptidoglycan)

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15. Cell wall is present in
(1) Plant cell (2) Prokaryotic cell (3) Algal cell (4) All of the above

16. The average thickness of plasma membrane is
(1) 150 Å (2) 70 Å (3) 60 Å (4) 158 Å

17. Middle lamella is chemically formed of
(1) Cellulose (2) Hemicellulose (3) Pectin (4) Lignin

18. Vacuolar membrane of a cell
(1) Plasmalemma (2) Tonoplast (3) Rhizoplast (4) Mesosome

19. The cell wall of most fungi is made of
(1) Lignin (2) Suberin (3) Chitin (4) Pectin

20. The transportation of materials in the cell is done by
(1) Ribosomes (2) Lysosomes (3) Mitochondria (4) ER

21. An old living plant cell is characterized by the
(1) absence of vacuole (2) presence of two nuclei
(3) absence of nucleus (4) presence of large vacuole

22. Ali performed an experiment in which he put two different cells P and Q in pure water, P swelled up and burst eventually while cell Q became tight and firm but did not burst.
Which of the following is the most appropriate inference?
(1) Cell sap of cell P is isotonic to the pure water.
(2) Cell sap of cell Q is isotonic to pure water.
(3) Cell P has been obtained from a plant.
(4) Cell Q is a bacterium.

23. The plant cell wall possesses
(1) Cellulose (2) Hemicellulose (3) Pectin (4) All of these

24. DNA is found in
(1) Smooth endoplasmic reticulum (2) Ribosome
(3) Nucleus (4) Lysosomes

25. The genetic material in the cell is
(1) m-RNA (2) r-RNA (3) t-RNA (4) DNA

26. All organelles are contained by the
(1) Cell membrane (2) Nuclear envelope
(3) Thylakoid membrane (4) None of the above

27. The part of the cell responsible for maintaining cell shape, internal organization and cell movement is the
(1) Vesicle (2) Nucleus
(3) Endoplasmic reticulum (4) Cytoskeleton

28. Nucleoid is present in
(1) Plant cell (2) Animal cell (3) Green algal cell (4) Bacterial cell

29. Which structure includes all of the other structures?
(1) Nucleolus (2) Nucleus (3) Chromosome (4) Genes

30. The organelle having flattened cisternae near the nucleus is
(1) Mitochondria (2) Nucleolus (3) Centrosome (4) Golgi apparatus

31. Which one takes part in acrosome formation?
(1) Golgi apparatus (2) Lysosome (3) Nucleus (4) Mitochondria

32. The Golgi apparatus is involved in
(1) Transporting proteins that are to be released from the cell
(2) Packaging proteins into vesicles
(3) Altering or modifying proteins
(4) All of the above

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33. Ribosomes are made up of
(1) Proteins (2) Lipids
(3) RNA (4) Both (1) & (3)

34. Aerobic respiration takes place in
(1) Glyoxisomes (2) Mitochondria
(3) Lysosomes (4) Chloroplasts

35. Besides nucleus DNA is also present in
(1) Ribosomes (2) Mitochondrion
(3) Lysosomes (4) Golgi complex

36. The plastids which make flowers and fruits conspicuous to animals for pollination and dispersal are
(1) Chloroplast (2) Chromoplast
(3) Leucoplast (4) None of these

37. The type of plastids commonly found in the cells that are not exposed to light are
(1) Leucoplasts (2) Chromoplasts
(3) Chloroplasts (4) All plastids

38. Within chloroplasts, light is captured by
(1) Thylakoid within grana (2) Grana within cisternae
(3) Cisternae within grana (4) Grana within thylakoids

39. Detoxification site in the liver cell is
(1) Golgi apparatus (2) Free ribosomes (3) RER (4) SER

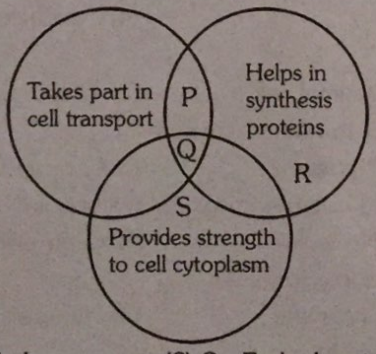
40. Which of the following is not present in prokaryotes?
(1) DNA (2) Cell membrane
(3) Cell wall (4) Endoplasmic reticulum

41. In which of the following is endoplasmic reticulum absent?
(1) Cells of pancreas, salivary glands (2) Erythrocytes of mammals and prokaryotes
(3) Cells of brain (4) Nephrons

42. Which of the following is useful for the synthesis of proteins and enzymes?
(1) SER (2) Golgi complex
(3) RER (4) Mitochondria

43. Semi-autonomous and self replicating cell organelles are
(1) Lysosomes (2) Mitochondria
(3) Ribosomes (4) ER

44. Refer the given Venn diagram and select the correct option.



(1) P - Golgi apparatus; R - Microtubules (2) Q - Endoplasmic reticulum; R - Ribosomes
(3) S - Microtubules; Q - Ribosomes (4) S - Golgi apparatus; P - Lysosomes

45. Ribosomes are made up of _____ subunits.
(1) 1 (2) 2
(3) 4 (4) 3

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46. Proteins synthesized by the rough ER are generally
(1) Exported from the cell
(2) For internal regulation
(3) For internal storage
(4) To digest food in lysosomes

47. The smallest cell organelle is
(1) Mitochondria (2) Microfilament
(3) Microtubule (4) Ribosome

48. Which of the following is not membrane bound?
(1) Sphaerosome (2) Mitochondria
(3) Ribosome (4) Lysosome

49. If the ribosomes of a cell are destroyed then
(1) Respiration will not take place
(2) Fats will not be stored
(3) Carbon assimilation will not occur
(4) Proteins will not be formed

50. Which of the following is the most primitive cell organelle?
(1) Ribosome (2) Nucleus
(3) Mitochondria (4) Plastid

51. Centrioles and centrosomes occur in the cells of
(1) Green plants (2) Animals
(3) Bacteria and Cyanobacteria (4) Both (2) and (3)

52. Which of the following structures is usually present only in animal cells?
(1) Vacuoles (2) Cell wall
(3) Nucleus (4) Centrioles

53. Which cell organelle reduces the number of other organelles?
(1) Oxysome (2) Mitochondria
(3) Lysosome (4) None of these

54. Polymorphic cell organelle is
(1) Glyoxysome (2) Golgi complex
(3) Lysosome (4) Peroxisome

55. Organelle covered by a single unit membrane is
(1) Peroxisome (2) Glyoxysome
(3) Lysosome (4) All of these

56. Enzymes for changing fats to carbohydrates occur in
(1) Golgi apparatus (2) Glyoxysomes
(3) Lysosomes (4) Sphaerosomes

57. Plants differ from animals in having
(1) an endoplasmic reticulum (2) a central large vacuole
(3) golgi complexes (4) vesicles

58. Store houses of the cell are
(1) Mitochondria (2) Chloroplast
(3) Nucleus (4) Vacuoles

59. Mitochondria are absent in
(1) Green algae (2) Bacteria
(3) Red algae (4) Brown algae

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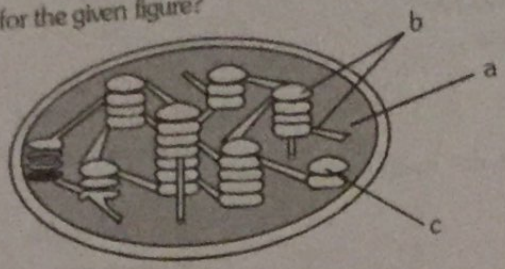
60. Which of the following is an incorrectly matched pair?
(1) Autolysis of cell - Peroxisomes
(2) Control centre of the cell - Nucleus
(3) Units of hereditary characteristics - Genes
(4) Formation of spindle fibres - Centrioles

61. Which of the following is correct for the given figure?



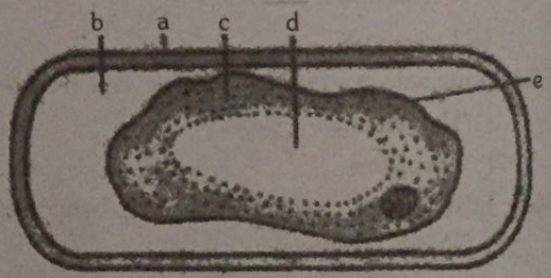
(1) The part labelled 'b' is called thylakoid.
(2) The part labelled 'c' is called granum.
(3) The part labelled 'a' is the site of dark reaction.
(4) The parts labelled 'a', 'b' & 'c, all possess chlorophyll containing photosynthetic pigments.

62. Correct the given statements by replacing the underlined words and select the correct option.
(i) The viscous fluid present in the nucleus is called <u>cytoplasm</u>.
(ii) <u>Vacuoles</u> are rod shaped structures which oxidize food to provide energy.
(iii) <u>Mitochondria</u> contain green pigment chlorophyll and take part in photosynthesis.
(iv) <u>Lysosomes</u> take part in synthesis of protein.

	(i)	(ii)	(iii)	(iv)
(1)	Nucleoplasm	Lysosomes	Plastids	Centrosome
(2)	Protoplams	Ribosomes	Centrosome	Golgi bodies
(3)	Nucleoplasm	Mitochondria	Chloroplasts	Ribosomes
(4)	Protoplasm	Plastids	Endoplasmic reticulum	Ribosomes

63. The given figure represents a plant cell after being placed in a strong sugar solution. The different parts have been labelled as a, b, c, d & e. Which of the following is the correct labelling?

	a	b	c	d	e
(1)	Cell wall	Sugar solution	Protoplasm	Vacuole	Cell membrane
(2)	Cell membrane	Sugar solution	Protoplasm	Vacuole	Cell wall
(3)	Cell wall	Sugar solution	Vacuole	Protoplasm	Tonoplast
(4)	Cell membrane	Sugar solution	Vacuole	Protoplasm	Tonoplast



64. Match Column I with Column II and select the correct option from the codes given below.

	Column I		Column II
(a)	Suicidal bag of the cell	(i)	Mitochondria
(b)	Power house of the cell	(ii)	Ribosome
(c)	Protein factory of the cell	(iii)	Lysosome
(d)	Kitchen of the cell	(iv)	Endoplasmic reticulum
(e)	Circulatory system of the cell	(v)	Chloroplast

(1) a-(iii), b-(i), c-(ii), d-(iv), e-(v)
(2) a-(iii), b-(i), c-(iv), d-(v), e-(ii)
(3) a-(iii), b-(i), c-(ii), d-(v), e-(iv)
(4) a-(i), b-(iii), c-(ii), d-(v), e-(iv)

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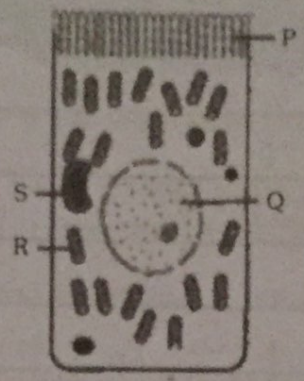
65. Refer the given figure of a cell. Which organelle is more in number? Also, identify among P, Q, R and S, the organelle which is responsible for transmission of hereditary information.



(1) Endoplasmic reticulum; P
(2) Mitochondria; Q
(3) Ribosome; R
(4) Golgi body; S

ANSWERS

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	4	3	2	2	3	1	4	2	3	2	2	2	1	4	4
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	2	3	2	3	4	4	4	4	3	4	1	4	4	2	4
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	1	4	4	2	2	2	1	1	4	4	2	3	2	2	2
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	1	4	3	4	1	2	4	3	3	4	2	2	4	2	1
Que.	61	62	63	64	65										
Ans.	3	3	1	3	2										

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